Electrical Anomalies Observed During DC3

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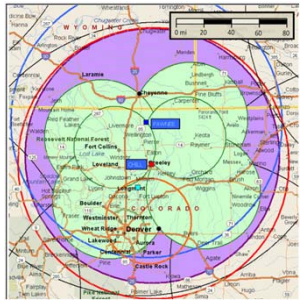
1. Introduction

The primary scientific goals of DC3 involved improving our understanding of the chemical impacts of thunderstorms and their anvils. However, the Colorado domain provided opportunities to study other interesting phenomena, including the potential impacts of smoke ingestion on convection and thunderstorms, electrification processes in smoke plumes and pyrocumulonimbus clouds, and the production of sprites by unconventional thunderstorms.

2. Data

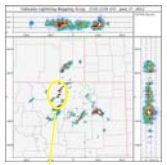
- CSU-CHILL Polarimetric Doppler Radar
- CSU-Pawnee Doppler Radar
- NOAA NMQ Radar Mosaics
- NMT Colorado LMA (COLMA)
- Vaisala NLDN
- GOES Visible and IR
- Suomi NPP Satellite

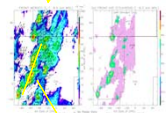


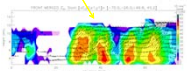
DC3 Colorado Domain

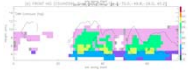
3. Smoke Impacts on Thunderstorm Electrification?

Summary: Did the major fire activity and smoke in the Colorado domain during DC3 cause anomalous electrification of thunderstorms (i.e., “inverted storms”)? Case studies of inverted and normal-polarity charge structures in adjacent “garden variety” convection may offer a way to test this hypothesis.

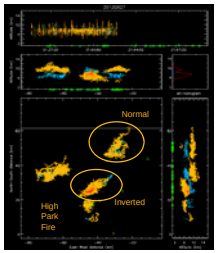


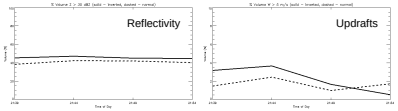






Conventional airmass thunderstorms over the foothills featured vastly different charge structures on 27 June 2012. Inverted storms were found downwind of the High Park burn area, while normal-polarity storms occurred further away.





The normal (dashed) and inverted (solid) polarity storms presented similar updraft and reflectivity statistics, despite their vastly different charge structures.

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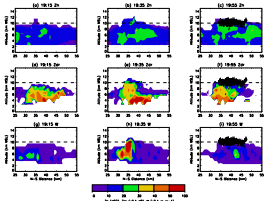
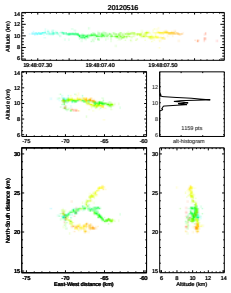
4. Electrification of Pyrocumulonimbus Clouds Above Wildfires

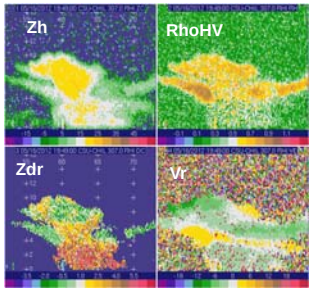
Summary: Pyrocumuli above three Colorado forest fires (Hewlett Gulch, High Park, and Waldo Canyon) electrified and produced small intracloud discharges whenever the smoke plumes grew to high altitudes (over 10 km MSL). This normally occurred during periods of explosive wildfire growth. The lightning, detected by COLMA but not NLDN, mainly occurred downwind of the fires, and likely was driven by ice crystal-based electrification processes that probably did not involve significant amounts of riming graupel.



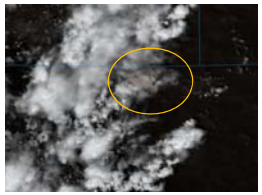
Evolution of Hewlett Gulch plume reflectivity (a-c), differential reflectivity (d-f), and updraft speed (g-i). The strong updrafts in the plume’s core preceded by several minutes the lightning downwind.



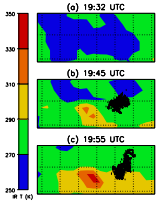
Typical example of IC discharge in Hewlett PyroCb. Note the compact size, and the discharging toward the NE (with the wind). These flashes commonly were preceded by 30+ seconds of precursor activity.



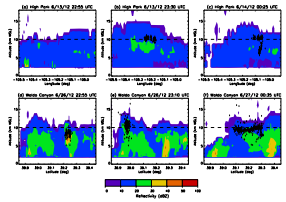
Polarimetric radar data in the electrified Hewlett plume. There were vertical gradients in correlation coefficient and differential reflectivity, consistent with increasing amounts of small ice aloft. Lightning initiated near this upper region and propagated downwind into very low reflectivity. Lower in the plume, the signal is dominated by smoke and ash with low reflectivities, suggesting minimal graupel.

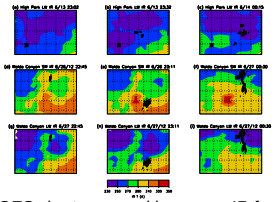


Suomi NPP VIIRS true color imagery near time of Hewlett electrification. Smoke is colored with a brown tinge.



GOES shortwave IR detected a hot spot occurring nearly coincidentally with lightning in the Hewlett plume. This suggests significant fire growth caused the plume development and subsequent lightning



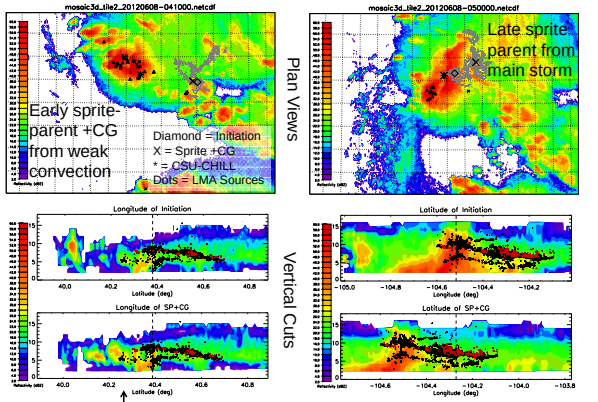


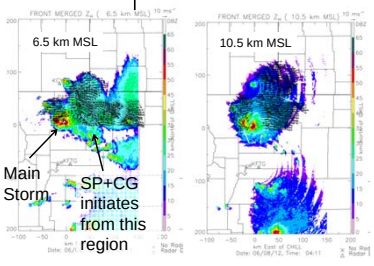
GOES shortwave and longwave IR for High Park (a-c) and Waldo (d-i). Waldo featured another strengthening hot spot while High Park was obscured by cold cloud.

Evolution of plume reflectivity and lightning above High Park (a-c) and Waldo Canyon (d-f) fires. The electrification behaved similarly to Hewlett. Note the electrical interaction between the Waldo plume and a conventional thunderstorm to its north.

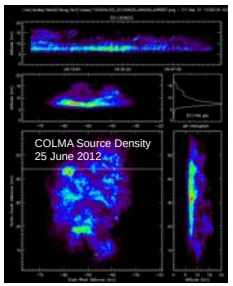
5. Sprites in the Colorado Domain

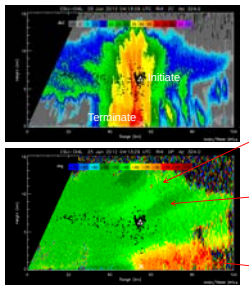
Summary: Two storms (8 and 25 June 2012) produced photographed mesospheric sprites within the COLMA. Portions of these storms also were scanned by Colorado DC3 radars, providing an unprecedented look at the microphysical structures of unusual sprite-producing storms.





The severe hailstorm on 8 June produced sprites, especially late in its lifetime. The behavior of the parent lightning was conventional, with initiation in convection and the +CG occurring outside convection. Even small cells produced sprites by initiating flashes that tapped copious charge likely being advected away from the main thunderstorm.





In contrast to 8 June, the 25 June storm produced sprite-parent +CGs within convection. COLMA data indicated the storm was clearly inverted, and the +CGs initiated and terminated within the deep convective cores. The parent flashes discharged mid-level portions of the storm’s anvil. Polarimetric data indicated alternating horizontal and vertical ice crystal alignment near major lightning regions. This case may provide a model for explaining the occasional production of sprites over smaller convective storms.